

AN EVALUATION OF MENSTRUAL AGE VERSUS  
RADIOLOGICAL ESTIMATION OF GESTATIONAL AGE  
BY PLAIN SKIAGRAMS IN THIRD TRIMESTER  
OF PREGNANCY

THESIS  
FOR  
DOCTOR OF MEDICINE  
( RADIO-DIAGNOSIS )



**BUNDELKHAND UNIVERSITY  
JHANSI (U. P.)**

\*\*\*\*\*  
GODS PLACED DIAGNOSIS BEFORE THERAPY

- FRANZ VOLLMARD

(An outstanding physician)

C E R T I F I C A T E

This is to certify that the work in connection with the thesis entitled " AN EVALUATION OF MENSTRUAL AGE VERSUS RADIOLOGICAL ESTIMATION OF GESTATIONAL AGE BY PLAIN SKIAGRAMS IN THIRD TRIMESTER OF PREGNANCY", which is being submitted as a thesis for M.D. (RADIO-DIAGNOSIS) by Dr. BEENA JAIN was carried out in the Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi.

She has put in the necessary stay in the Department as per university regulations.

  
( H.N. SAXENA )  
M.D., D.M.R.E.,  
Professor and Head,  
Department of Radio-Diagnosis,  
M.L.B. Medical College Hospital,  
Jhansi.

Dated :

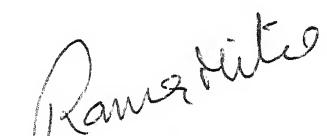
C E R T I F I C A T E

This is to certify that the work in connection with the thesis entitled " AN EVALUATION OF MENSTRUAL AGE VERSUS RADIOLOGICAL ESTIMATION OF GESTATIONAL AGE BY PLAIN SKIAGRAMS IN THIRD TRIMESTER OF PREGNANCY", was carried out in the Department of Radio-Diagnosis under our guidance and supervision by Dr. BEENA JAIN. The techniques and observations embodied in this thesis have been undertaken by the candidate herself and checked by us.



( H.N. SAXENA )  
M.D., D.M.R.E.;  
Professor and Head,  
Department of Radio-Diagnosis,  
M.L.B. Medical College Hospital,  
Jhansi.

( GUIDE )



( RAMA MITRA )  
M.S., D.G.O.;  
Professor and Head,  
Department of Obstetrics  
and Gynaecology,  
M.L.B. Medical College  
Hospital, Jhansi.

( CO-GUIDE )

Dated:

## ACKNOWLEDGEMENTS

The act of creating, of bringing into being of something that did not exist before, gives us humans our most intense and primary satisfaction. This satisfaction approaches fulfillment when one is fortunate to have the extremely able and devoted guidance of a teacher like Dr. H.N. Saxena, M.D., D.M.R.E., my guide, and Professor and Head, Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi. His breadth and depth of knowledge, his sustained support throughout "spring and autumn" of the present study in all it's aspects from the selection of cases to the preparation of the script, shall be cherished for times to come. He not only piloted the study but also ensured it's smooth completion, ironing out the problems. He was very prompt in letting me out of the "anxious moments" as and when they arrived. He gave generously of his time, and labored through the long and arduous task of editing the manuscript, proof reading every page, providing organisation to the perpetually disorganised script. Unfailingly he tolerated numerous mistakes of mine. His seemingly limitless dedication, insight and enthusiasm will always remain a part of me henceforth. For me he is ever a "father-figure" guiding me and providing me strength and hope in moments of despair.

I consider it very precious to have the honour of acknowledging a large debt of gratitude, credit and thankfulness, to my Co-guide Dr. Rama Mitra, M.D., D.G.O., Professor and Head, Department of Obstetrics and Gynaecology, M.L.B. Medical College Hospital, Jhansi, for her prompt and kind permission to permit me to carryout the examination of her patients. Her continuing interest and co-operation in selection of cases was indispensable to the eventual completion of the present work on time. Without her help and expert guidance, successful outcome of this enterprise may not be contemplated.

I must acknowledge the highly valued assistance of my respected teacher Dr. A.K. Gupta, M.D., Associate Professor, Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi, who gave very generously of his time, and advise during the entire period. His breadth and depth of knowledge, his expertise as a teacher are well acknowledged.

I am pleased to have this opportunity to acknowledge my indebtedness to Dr. T.B.L. Jaiswal, M.D., D.M.R., Associate Professor, Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi, whose expert guidance was imbibed through out the period of study.

I express my gratitude to Dr. G. Kumar, M.D., Assistant Professor, Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi, for his everhelping nature and expert guidance that gave me the courage to complete this work.

My sincere thanks to Dr. (Mrs.) Usha Agarwal, M.D., Associate Professor, Department of Obstetrics and Gynaecology, M.L.B. Medical College Hospital, Jhansi, who gave me kind permission to examine her patients. Her dedication to this study went for beyond duty.

My colleagues and friends have helped in innumerable ways, I wish to offer my thanks to all of them.

Not to be forgotten is the contribution of technical staff of Department of Radio-Diagnosis, M.L.B. Medical College Hospital, Jhansi in their help and assistance.

A measure of thanks is also due to Mr. K. Lal who patiently and expertly shepherded the manuscript to it's finally typed form.

Finally, I remember, I shall never be able to rewind those little years, which my little son has lived through, albeit without me.

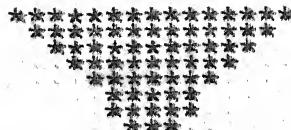
*Beena Jain*

Dated: 18-1-93

( BEENA JAIN )

## C O N T E N T S

	<u>PAGE NO.</u>
INTRODUCTION .....	1 - 5
REVIEW OF LITERATURE .....	6 - 31
MATERIAL AND METHOD .....	32 - 35
OBSERVATIONS AND RESULTS .....	36 - 56
DISCUSSION .....	57 - 68
SUMMARY AND CONCLUSION .....	69 - 72
BIBLIOGRAPHY .....	I - III



\*\*\*\*\*  
I N T R O D U C T I O N  
\*\*\*\*\*

## INTRODUCTION

Accurate knowledge of foetal age is important under several circumstances. It helps the pregnant women, her family, the obstetrician and the radiologist in the planning of pregnancy, in the prediction of maturity and the detection of growth retardation. The estimation of intrauterine age often presents a problem in medical emergencies induction of labour or when elective caesarean section is indicated. Since perinatal mortality and morbidity is decreased if fetus is mature at the time of delivery. It is also helpful when patient has no record of L.M.P. or may conceive during lactational amenorrhoea.

It is a tradition to know fetal age by abdominal palpation, but it has its own limitations if the patient is very fatty or there is much liquor or patient does not relax her muscles. The gestational age estimated by menstrual history or uterine fundal height, contain inaccuracies even in the best of circumstances.

It has been estimated that menstrual history is not reliable in atleast 20% of the women for reasons that may include - oligomenorrhoea, bleeding in the first trimester, and becoming pregnant in the post partum period, or after the use of oral contraceptives or intrauterine

devices. In women with optimal menstrual histories only 85% delivered within  $\pm$  two weeks of their estimated date of confinement (EDC), decreasing to 70% in women uncertain of their dates.

The different terms that are commonly used to indicate the duration of pregnancy and thus fetal age is some what confusing. Menstrual age or gestational age is estimated from the first day of L.M.P. or about two weeks before the ovulation and fertilization or nearly three weeks before implantation of the fertilized ovum. About 280 days (40 weeks) elapse on an average between first day of L.M.P. and delivery of the infant. The usual practice is to calculate the gestational age on the basis of menstrual age of a given pregnancy.

A new born infant is considered premature when he is incapable of independent uncomplicated extrauterine life and meets any or all of the following objective criteria.

- (1) Birth weight below 2500 gm
- (2) Gestation of less than 37 weeks
- (3) Length (crown-heel) less than 47 cm
- (4) Head circumference less than 33 cm.

A new born infant is considered postmature when the gestation is known to be longer than 42 weeks or when the characteristic clinical features are present. This consists of dry, wrinkled, scaly skin often stained with meconium, long fingernails, and hair. Radiologically presence of large ossification centres with identifiable trabeculations and increased thickness of diaphysis of long bones are signs of postmaturity.

Now more sophisticated and specialized techniques have been used for precise assessment of foetal age. Amniotic fluid can be used for the estimation of foetal maturity but it is not done in routine practice. Ultrasonography is new modality and commonly used to assess the fetal maturity and growth. By ultrasound fetal gestation sac can be first detected in the uterus at five weeks of menstrual age. While radiographically detectable fetal skeletal parts are difficult to find before 13-14 weeks. Due to radiation hazards to the fetus pregnant women should not be radiographed in first and second trimester of pregnancy.

Many bone parameters have been advocated for assessment of gestational age by radiography. The largest of long bones, the femur, is easiest to image and measure as accurately as any other long bone. The femur measurement

4

is also of value in the detection of foetal skeletal dysplasias. The femur is measured along the long axis of the diaphysis of the osseous portion of the shaft.

At one time the biparietal diameter (BPD) was the most discussed and documented obstetric measurement. The B.P.D. is taken in the transaxial plane at the widest portion of skull, but proved too difficult and has been dropped out of use.

Inspite of all the drawbacks knowledge of assessment of fetal age by plain skiagram is necessary. Because the facilities of ultrasound are not available everywhere, and it is too costly for the patient.

Review of literature reveals that radiological examination of the osseous development of the fetus constitutes a reliable means of estimating physiological foetal age. Of the factors studied, particular attention was paid to the ossification in the lower limb centers, long bones measurements, diameters of skull, length of lumbar spine curve.

Hartley (1957), published data of development of the skeleton as a whole and gave the periods of appearance of various ossification centres. Schreiber, M.H. (1963), indicate that when this center is present and radiographically

identifiable on antepartum films a mature foetus is present in 96 percent of cases but Dee, Perkin, and Simpson, (1966), have questioned the reliability of these centers.

Brandfass and Howland, (1966), describe a simple method of determination of foetal weight by long bone measurements on pelvimetry or maternal abdominal films with 90 percent accuracy. R.H. Owen (1970), and Martin (1971), have independently worked and found a definite relation in growth of long bones and gestational age.

Alan J Margolis (1967), reported relationship between lumbar vertebral and new born length. Similar findings have previously been reported by Fagerberg and Ronema (1959). The accuracy of this method was 95%.

Bundelkhand region being an economically backward region, the patients are largely unable to afford the newer modalities like ultrasonography. This along with a paucity of work, in India, on the estimation of gestational age by plain skiagrams, prompted us to undertake the present study based on the underlying concept that the rate of growth of foetal bones is related to the foetal age.

-----

\*\*\*\*\*  
REVIEW OF LITERATURE  
\*\*\*\*\*

## REVIEW OF LITERATURE

Radiological examination of osseous development of the foetus include various parameters like -

- (1) Length of the femoral shaft
- (2) Length of the lumbar spine
- (3) Biparietal diameter of the skull
- (4) Occipitofrontal diameter of skull
- (5) Distal femoral epiphyseal ossification centers, their presence, size, and characteristics.
- (6) Proximal tibial epiphyseal ossification centers, their presence, size and characteristics.

All the above methods have variable applicability and reliability as shown by various workers. The literature available on this subject to determine the foetal maturity is arranged in chronological order.

Hodges (1937) prepared a series of combined equation graphs from the work of Scammon and Calkins (1929). These graphs show the average age of the foetus in relation to various foetal measurements such as the occipitofrontal diameter, the biparietal diameter, the perimeter of the skull, or the length of the femoral shaft.

Amos Christie, Margaret Martin et al (1950) studied 1,112 newborns. They found that the proportion of infants having each of several centres of ossification increases with weight. They observed that distal epiphysis of the femur usually appearing by the thirty six weeks of gestation, was present in most infants weighing over 2500 grams. So that its absence probably indicates an immature or just barely mature infant. The proximal epiphysis of the tibia develop some what later (appearing by 39 to 40 weeks) and was found in only two infants weighing under 2000 grams. Thus its presence was indicative of a mature or nearly mature infant. Whereas there was individual variability in the development of these centres, they appear to be fairly good indices of maturity, particularly if size of centre as well as its presence or absence was taken into account. After these observations authors felt a need for evaluation of a method on a series of roentgenograms of foetal parts and undertook a study to determine whether the estimates so obtained were sufficiently valid to be useful.

For their study the authors took an antero posterior and a right anterior oblique roentgenogram.

Author studied 100 such roentgenograms and following items were recorded from the roentgenogram alone.

- (1) The presence or absence of the distal epiphysis of the femur and of the proximal epiphysis of the tibia
- (2) The estimated weight of the fetus
- (3) The estimated number of weeks of gestation

Then as a basis for evaluation the following information was taken from the histories of the mother and baby.

- 1- The weeks of gestation at the time of roentgenogram as calculated from the menstrual history.
- 2- The weight and length at birth.

The authors observed that in the group with neither centre present, the fetuses were, with two exceptions, immature or just barely mature at the time of roentgenogram.

At the other extreme, all the foetuses with both centres weighed over 2,500 grams with the exception of two female foetuses.

In group with the epiphysis of femur present, and the epiphysis of the tibia absent, 37 cases were studied, in which thirteen weighed under 2,500 grams but seven of the thirteen weighed over 2,250 grams, indicating border line maturity. This would mean that about 20% of the foetuses with only one of centres present were definitely immature. Thus on the basis of presence or absence of the centres alone, foetuses in this group would be judged "probably mature".

Then the authors compared the weight as estimated from the roentgenogram, to the birth weight. This study includes only babies born within a week of the roentgenogram. Thirty eight out of fifty or seventy five percent, of the cases differed by less than 500 grams. Forty six or ninety two percent cases differed by less than 750 grams.

After this study the authors made a conclusion that the method shows promise and that it very likely could be improved with further study. On the other hand, it can be expected that there would be a certain proportion of failures which was due either to imperfection of roentgenograms or to individual variability in the development of centres of ossification.

Chassar Moir (1955) present a table of average dates of appearance of ossification centres of lower epiphysis of the femur, which appears between the 35th and 40th week and the upper epiphysis of the tibia which appears at the 40th week. These are described as merely average dates, subject to much individual variation.

Hartley (1957) published data of development of the skeleton as a whole and gave the dates of appearance of various ossification and epiphyseal centres, particularly those of calcaneum, cuboid, tibial, and lower femoral epiphysis. The author said that the foetus can not be identified on the roentgenograms of the maternal abdomen before the tenth week and it is uncommon to visualize the foetal skeleton before the 12th week.

At 10th weeks ossification centers appear for the vertebral bodies beginning at about the 12th dorsal vertebra and progressing cephalad and caudad. At 12 weeks the bony pattern becomes better organized and centres are visible in the spine in the lateral view. The skull can be faintly seen, and the ribs become visible. At 24 weeks the long bones of the extremities are well seen. The contour of the head can be outlined and the bones of the base of the skull are visible. The metatarsals are identifiable, though they are often superimposed upon the maternal spine.

From 24 to 26 weeks the calcaneum becomes radiographically visible and between 26 to 28 weeks the talus, having a granular and multifocal appearance, become visible. Within the next four weeks the talus becomes better organized and well defined.

From 36 weeks onward well developed bony structures are seen in all major parts of the skeleton. Trabeculae become fairly well defined. The distal femoral epiphyseal ossification center is present in over 80 percent of infants from the 36 weeks onward. It is wider than it is tall. The proximal tibial epiphyseal ossification center appears at about the thirty eighth week. It is ill defined at this time but becomes clearly seen by 40 weeks gestation with a trabecular structure and a clearly visible cortex.

Duncan Murdoch and Ian Cope (1957) chose 100 cases of apparently normal infants born of healthy normal white women, to determine the range and variety of appearances of different ossification centres which may be expected at maturity. The mother of these infants were those with regular menstruation, and with an accurate memory of the last menstrual period, and who had an uncomplicated pregnancy and delivered within three days of the predicted date of delivery. Radiographs of knee and ankle joints were obtained shortly after birth.

The authors observed, at knee joint, that lower femoral epiphysis was present in 99 out of 100 cases examined, and were judged to be sufficiently well calcified to be visible by radiography before birth in at least 78 cases.

The epiphysis of the upper end of the tibia was present in 72 of the 100 cases and was well developed and well calcified in 39 cases.

The cuboid was ossified in 28 of the 100 cases and well developed and well calcified in 13 cases. Its multicentric ossification was noted.

The authors concluded that all the infants of this series were of the same physiological maturity in terms of gestational time and that the difference found in the ossification centers were physiological variations occurring in normal pregnancy at term. Marked development of any of these centres may be observed in normal maturity and therefore such a finding is not evidence of post maturity.

Ian Cope and J. Duncan Murdoch (1958) said that another method of obtaining infants of equivalent maturity was examination of twins. According to them if there was marked difference in ossification centres of individual of

twin set there would be conclusive evidence that certain factor, other than period of gestation can greatly modify the time of appearance and size of epiphyseal centre.

They examined 11 twin set for lower femoral and upper tibial epiphysis and of the cuboid. There were 7 sets of normal twins of like sex : in all of them ossification was developed fairly equally in the siblings and ossification was advanced in the heavier twin.

There were 3 twin sets of unlike sex. Female twin showed more advanced ossification than the male: which accords with previous observations in singlets of apparently similar gestation age.

Authors made a conclusion that twin pregnancy which provide a certain method of comparision of individual of exactly equivalent maturity, wide variation in epiphyseal ossification were present.

F.R. Berridge and Bruce Eton (1958) studied 200 cases for determining accuracy of radiological estimation of foetal maturity. Initially anteroposterior films and lateral films were taken but afterwards posteroanterior films were substituted for the usual antero-posterior film & the effect of this was to reduce the apparent size of the foetus because of being nearer to the film. Authors made observation

that in 112 cases (56%), the estimate was correct to within one week or less. In 157 cases (78.5%) the estimate came within 2 weeks of the known maturity. They also observed that greater the maturity the more accurate was the method. It would be noted that of the cases where the radiological assessment was wrong, more maturities were over estimated (28% i.e. 56 cases) than were under estimated (16% i.e. 32 cases). Duration of pregnancy at the time of radiography ranged from 23 to 43 weeks.

The authors said that possible sources of error of estimated maturity were :-

- (1) Available films were unsatisfactory.
- (2) Presence of centres in the knee at 32 weeks led to over estimated maturity in 4 cases. On the other hand 4 cases were under estimated with no centre being present at 37-39 weeks. It would seem that the presence or absence of centres may be equally misleading.
- (3) Size of child : Maturity was under estimated if the child was small and over estimated if it was large.

- (4) Small stature of the mother did not have significant influence.
- (5) Where the mother was above average weight (over 82 kg), maturity was over estimated, and in below average weight (under 59 kg) maturities were under estimated.
- (6) Sex of the foetus did not predispose to errors in the estimates.
- (7) Out of 14 sets of twins, wrong estimate was made in 6. Four were over estimated and 2 were under estimated.
- (8) The authors stated that malpresentation was a definite source of error.

From the above study, the authors made a conclusion that radiological estimation of maturity had its limitation and can not give absolute guidance.

Fagerberg and Ronema (1959) estimated foetal maturity by using length of lumber spine as a parameter. For this purpose they exposed a posteroanterior and lateral recumbent films of the abdomen at a target to film distance of 100 cm. The length of the fetal lumbar spine was measured on either of the films from the top

of the body of  $L_1$  to the bottom of the body of  $L_5$  and expressed in centimeters to the nearest half centimeter. No correction was made for size distortion. From the length of the lumber spine the crown to heel length may be predicted (plus or minus 3.4 cm). From this the length of gestation (in weeks) may be predicted.

The results obtained by Fagerberg and Ronema.

Lumber length (cm.)	Crown to heel length (cm $\pm$ 3.4)
4.0	42.0
4.5	45.0
5.0	47.5
5.5	50.6
6.0	54.0

Melvyn H. Schreiber and Louis Menachof et al in 1962 studied the reliability of visualization of the distal femoral epiphysis as a measure of maturity. He examined 1,935 new borns at birth. The radiograph of knee of all infants were taken. It was found that 95 percent of the total infants had radiographically visible distal

femoral epiphysis while 93.6 percent of the newborns were mature, remaining 1.4 percent of newborns were premature. Therefore reliability of distal femoral epiphysis was 98.6 percent.

Melvyn H. Schreiber et al (1963) made a study to investigate the reliability of intrauterine visualization of the epiphyseal centers for prediction of maturity. 296 pregnant women and infants were examined. Antepartum skiagrams in PA projection were taken and post partum films of infants knee were also taken. Distal femoral epiphyseal ossification centers were present on 217 films of knees and on antepartum films it was present in 173 cases. The distal femoral epiphyseal ossification centers demonstrated on abdominal films in 80% of the cases in which they were visualized subsequently on post partum films of the new born's knees. Four percent of infants with visible centers were not mature. So the author concluded that antepartum visualization of fetal distal femoral epiphyseal centers indicate a mature fetus from 92% to 98% (average 96%).

P.M. Dee, J.M. Parkin, and W. Simpson (1966) opined that there were wide differences in the stated time of appearance of the lower limb centres as quoted by various authorities.

For reappraisal of the relationship between gestational age and the development of the lower limb ossification centres the author under took a study. New born babies whose gestational ages, calculated from reliable menstrual histories were the subject of study. The authors felt that radiograph taken with in a few hours of birth would show a state of osseous development corresponding to that present immediately before delivery. There were two advantages in studying new born babies rather than foetus in utero. First the radiological technique could be standardised to a much greater extent and a more accurate estimate of the presence and size of the ossification centres could be obtained, thus allowing the best possible correlation between these factors and gestational age to be determined. Second the total dose of radiation could be reduced to a very low level particularly if only localised views of the areas of interest were taken and the baby's body and gonads adequately protected.

They took the radiographs of the right knee and ankle only and protected the rest of the body. Radiographs were taken with in 72 hours after birth. In order to reduce errors due to magnification and distortion a film focus distance of 36 inches was used and particular attention

was paid to placing the limb in the true lateral position in close apposition to the cassette.

Authors limited the analysis to the age group of 252 days (36 weeks) and over. They concluded that calcaneum and talus were invariably present in the all cases.

The lower femoral centres was present in all but two, before 38 weeks, and was invariably present after 266 days (38 weeks). Thus failure to identify a lower femoral epiphysis could be accepted as valid evidence that the age of the foetus was less than 266 days (38 weeks).

The upper tibial centre was absent in 12 (12.5%) out of the 95 cases after 266 days (38 weeks) and in one case it was still absent at 297 days (42 weeks). Between 252 and 266 days (36 - 38 weeks) it was present in 8 out of 14 cases (57%). Therefore no reliable conclusions could be drawn from the presence or absence of this centre.

The cuboid was present in 50 (47%) of 107 cases in which this assessment was possible. Before 280 days (40 weeks) it was present in 22 out of 50 cases (44%) and after 280 days (40 weeks) it was present in 28 out of 57 cases (49%).

The degree of correlation between the size of the centre and gestational age was calculated. It was found that there was poor correlation between the size of each centre and the gestational age. The appearance and size of the lower femoral epiphysis was the only radiological measurement that correlates better. The authors calculated that by using the size of the lower femoral epiphysis in 95% of cases the gestational age of the baby can be predicted no more accurately than to within a range of  $\pm$  7 weeks.

Authors made a conclusion from these findings was that study of ossification centres on an antenatal radiograph is an unsatisfactory method of assessing the gestational age of a foetus.

Robert T. Brandfass, and Willard J. Howland (1966) undertook a study to determine the foetal weight by long bone measurements. According to them single measurement may be inaccurate because of foetal position, maternal weight variation, and indistinct outline due to foetal movement. Authors chose multiple measurements like length of each femur, tibia, radius, ulna and humerus. The control part of this study was obtained by measuring these bones of new born infants by teleroentgen radio -

graphs. The roentgenograms were obtained with in 14 days after delivery of infants weighing 1500 and 3000 gms.

In control group they found that following measurements were most accurate indicators of a weight of 2250 gram (5 lb) or more.

Femur	-	8.6 cm
Tibia	-	7.0 cm
Humerus	-	7.5 cm
Ulna	-	6.8 cm
Radius	-	5.6 cm

The second portion of this study consisted of intrauterine measurements of the ten long bones from 100 pelvimetry or abdominal roentgenograms made with in 14 days before delivery.

The authors observed that a total of 10 measurements was not always achieved and the smaller of two corresponding bone lengths was discarded as representing some element of angulation. If any of the bones were found to equal or exceed in length from the length of corresponding bone in control group, they concluded that the foetus should weigh 2250 grams (5 lb) or more. In contrast if all the measurements were less than the reference figures the weight should be less than 2250 grams.

After studying 100 foetuses following results were obtained:-

Group	Weight (grams)	No. of cases	Errors
A	2350 + (one measurement done)	51	4
B	2350 + (2 or more measurements done)	31	0
C	2150 - 2350	26	10
D	1500 - 2150	23	3

In group A all foetuses show one bone longer than standard except four. In group B, 2 or more bones measured more than the standard and there was no error. In group C some weighed over 2250 grams but had no measurements over the minimum criteria and a similar number weighed less but had longer bones than those accepted as standards. In group D, 3 foetuses had one bone which measured more than the predicted value.

The authors concluded that estimation of pre-partum foetal weight from long bone measurement was 90% accurate. Accuracy rate increased when 2 or more bones were measured.

Alan J. Margolis, and Richard C. Voss (1967)

estimated foetal maturity by measuring the lumbar vertebral length from antenatal X-ray films. Authors took a postero-anterior radiograph of abdomen in 175 single pregnancies within 15 days before delivery. Distance between the upper edge of the first lumbar vertebral body and the lower edge of the fifth lumbar vertebral body was measured following the curvature of the spine. Presence and absence of distal femoral epiphysis was also noted. New born length measurement was taken from the delivery record or nursery chart and recorded to the nearest centimeter. The measured lumbar vertebral length was then compared with the new born length, weight, duration of gestation.

The authors set out the relationship of lumbar vertebral length to total new born length as shown in table.

Measured lumbar in utero length (mm)	New born length (cm)
55	54 $\pm$ 5
54	53 $\pm$ 5
53	52 $\pm$ 5
52	51 $\pm$ 5
51	49 $\pm$ 5
50	48 $\pm$ 5
49	47 $\pm$ 5
48	46 $\pm$ 5
47	45 $\pm$ 5

The author reached the conclusion that a foetal lumbar length of 52 mm or more is clinically significant and that 95 percent cases of this group weighed more than 2,5000 gram and measured 49 cm or more in total length.

Dr. Theodore W. Adams, Portland, Oregon (1967) had reinforced the accuracy of Dr. Margolis study in normal pregnancies. During this study the author come across the observation that for babies of diabetic mothers, the crown heel length did not appear to hold the same relation to intra-uterine age as in normal pregnancies. They were 2 to 3 weeks ahead of their duration of gestation by estimations from foetal spine length.

J.G.B. Russell (1969), consultant Radiology in St. Mary's Hospital Manchester, said that an infant at term by dates may appear immature to paediatrician. An infant of less than 2.5 kg, premature by definition, yet may be well developed neurologically and mature by dates. Thus for determining the accuracy and value of the radiological assessment of foetal maturity he examined 3,606 patients radiologically. They also studied the effect of some physiological variables in the rate of maturation of the foetus when assessed radiologically.

First they calculated the predicted date of delivery from the date of the first day of the last menstrual period and the normal length of the menstrual cycle.

L.M.P. predicted date was calculated from formula. Date of first day of last menstrual period + 280 - 30 + length of menstrual cycle.

The radiologically predicted date of delivery was ~~reduced~~ from the recorded radiological assessment of foetal maturity and the date of that assessment. X-ray predicted date was obtained from formula. Date of X-ray (40 - X-ray maturity in weeks) x 7.

Then they calculated the errors of prediction and made a comparison between the errors of the predictions derived from the last menstrual period and from radiology for all the cases.

The error termed L.M.P. error =  
(delivery date - L.M.P. predicted date), and X-ray error = (delivery date - X-ray predicted date).

Thus a negative error was associated with an earlier than expected delivery, and a positive error with a late delivery. The magnitude of the error was expressed in days.

He made a result, that on average, the birth occurred earlier than predicted. Radiology was appreciably more accurate than the menstrual history in predicting the delivery date, the standard deviation from zero error being 20.8 days for the menstrual history and 16.9 days for radiology.

According to the author, parity, age of the mother, sex of the child, socio-economic status of the parents, weight of foetus, and season of the year, none had any significant effect on the rate of the radiological development.

While radiologically a twin pregnancy develops more slowly than a single pregnancy. He said that there was increased risk of dying in perinatal period, if the foetus is premature radiologically and a foetus postmature by dates does not run an increased risk so long as the radiological appearance does not indicate post maturity.

R.H. Owen (1970) estimate foetal maturity from direct measurements of the occipitofrontal diameter of the skull and the lengths of the long bones. The author used a technique in which films were taken with a standard anode film distance of 36 inches with the patient in the postero-anterior position. Only the bones which appeared to be parallel to the film were measured and measurement

were taken directly from the films with no correction for enlargement. He studied about 600 measurements of occipitofrontal diameter of the skull, femur, humerus, radius, ulna and tibia from 150 films at various stages of pregnancy from 12 weeks upto full term.

The means of the readings at each week of pregnancy were calculated. Results obtained by author.

TABLE

Week of gestation	Femur length in cm
24	6.6
26	7.0
28	7.3
30	7.6
32	7.8
34	8.0
35	8.1
36	8.2
37	8.1
38	8.2
39	8.3
40	8.4
At birth	9.0

R.H. Martin et al (1971) measured the thigh in new born child of gestational age 30 to 43 weeks which revealed that linear growth occurs at approximately 3 mm per week. This information was used to measure the length of the femur of the foetus in utero. The author took 190 X-rays of the foetus in utero upto 8 weeks before delivery. Length of femur was measured and following observations were made :-

Duration of gestation in weeks	Mean femoral shaft length in mm
32	62.5
33	66.0
34	69.0
35	71.5
36	74.5
37	77.5
38	80.5
39	83.5
40	86.5
41	89.0
42	91.0

The accuracy of prediction of gestational age was within one week, with a maximum error of not more than two weeks.

J.G.B. Russell et al (1972) undertook a study to verify the accuracy of methods, described by Owen (1970) and Martin (1971). He studied 217 skiagrams in postero-anterior projection. Measurements were made directly from the film. Femoral tibial and skull dimensions were most often obtained.

These dimensions were compared with the foetal maturity obtained from three other parameters as following :

1. From the menstrual history : The time from the last recorded menstrual period to the date of radiography was calculated to the nearest week.
2. From the radiological assessment : based on the knee and ankle bone development as described by Hartley (1957).
3. From the date of delivery : the time between the date of delivery and the date of radiography was estimated to the nearest week. The difference was subtracted from 40 and this was taken as foetal maturity at the time of radiography.

Results obtained by all three methods were compared. The author found that the correlation was poor. He concluded that rate of growth of femur was about 1.5 mm per week. But for a given length the range of maturity was too wide for useful application. So it had no significant advantage.

Kumar and Chawla (1978) studied 100 pregnant women in third trimester of pregnancy. The patients were referred for various indications. Author took the postero-anterior oblique views of the abdomen. Radiological criteria for assessment were (1) Measurement of skull (2) Length of femoral diaphysis (3) Length of lumbar spine (4) Foetal fat line (5) Ossification centers. They studied skull in all the cases and found that measurement was not reliable because there is wide discrepancy in size.

Measurement of long bones especially femur was done and observed that the foetus whose femoral shaft measurement more than 7.6 cm was of more than 36 weeks of gestation but there is also wide discrepancy between femoral shaft and period of gestation.

Lumbar vertebral lengths were measured from the upper border of  $L_1$  to lower border of  $L_5$ . It was observed that a foetus whose lumbar vertebral length was more than 5.1 cm was of more than 36 weeks gestation. Foetal fat line was also studied but it was found to be unreliable. Presence of the ossification centers of lower end of femur and upper end of tibia were noted. Authors found all the cases where the lower femoral center were visualized on the antenatal film were found to be mature by other indices and by clinical assessment of maturity at birth. Cases where the center around the knee were not present on antenatal films proved to be premature at birth.

-----

## MATERIAL AND METHOD

MATERIAL AND METHOD

The present study "EVALUATION OF MENSTRUAL AGE VERSUS RADIOLOGICAL ESTIMATION OF GESTATIONAL AGE BY PLAIN SKIAGRAMS IN THIRD TRIMESTER OF PREGNANCY" was carried out in Department of RADIO-DIAGNOSIS, Maharani Laxmi Bai Medical College & Hospital, Jhansi. A prospective study was carried out on 50 pregnant women in third trimester of pregnancy.

Following material was used in this study :-

- 1- X-ray films of size 12" x 15"
- 2- Cassettes and screen
- 3- 800 M.A. X-ray Machine
- 4- Developer and fixer solutions
- 5- Illuminating view box
- 6- Measuring scale

For this study fifty cases were selected from the Antenatal Clinic of Department of Obstetrics and Gynaecology, Maharani Laxmi Bai Medical College and Hospital, Jhansi. All the women attending antenatal clinic were inquired for their menstrual history, including the date of the last menstrual period. Complications occurring

during the pregnancy, previous pregnancies, and maturity of infant in previous deliveries. In multiparous women, a detailed history of previous pregnancy, whether eventful or not, and the maturity of the infant was obtained.

The criteria for selection of cases for the study were patients with a history of regular menstrual periods, an accurate knowledge of the date of last menstrual period, and an uncomplicated pregnancy. All patients were radiographed at differing weeks of gestation, during the third trimester of pregnancy. Patients attending the antenatal clinic during their third trimester of pregnancy, first time were inquired about their last menstrual period and history of any present or past complications. Postero-anterior view of the abdomen was taken in patients found suitable. If radiological assessment indicated any doubt, as to the accuracy of the duration of menstrual cycles and pregnancy, date of last menstrual period, then such cases were excluded from the study. Majority of cases, radiographed were followed upto delivery and the maturity of the foetus was assessed.

The series does not, therefore, include any case with an uncertain date of the last menstrual period.

X-ray Technique :

All the patients were radiographed in Radio-diagnosis Department of Maharani Laxmi Bai Medical College and Hospital, Jhansi. 800 M.A. X-ray unit was used because a short exposure time was required.

The patient was asked to lie flat in prone position on the X-ray table after emptying her bladder. The prone position while awkward, can easily be maintained by most pregnant women with help of pillows underneath the chest and knee. This diminishes the patients postero - anterior diameter significantly. Though it may occasionally accentuate fetal movement, to overcome this short exposure time was used and patient was asked to take a few long deep breaths to prevent foetal anoxia before suspending respiration during the actual exposure. Film focus distance was 100 cm. X-ray beam was centered over the third lumbar vertebra of mother. 80 to 90 KVP and 120 to 160 M.A. were used depending on the patients girth. Fast screen and films were used.

The X-ray films thus obtained were immediately processed and were thoroughly examined for -

- (1) Presence, if any, of overlapping of the femur, spine and knee joint with the maternal skeleton.

(2) Presence, blurring of femur, or lumbar spine, due to foetal movement.

If any of the above aberration was present, a second film was taken.

The following parameters were recorded from films selected for the study.

(1) Femur length;

The longer of the two bones was measured. The upper and lower ends of femur were marked on the film. The length between these two points was measured in straight line to the nearest millimeter.

(2) Lumbar curve length;

The upper end of the first lumbar vertebra and the lower end of the fifth lumbar vertebra were marked on the film and the distance through the middle of the vertebra was measured to the nearest millimeter by a flexible ruler bent to conform to the spinal curve.

(3) Presence or absence of distal femoral epiphyses was noted.

(4) Presence or absence of proximal tibial epiphyses was noted.

-----

## O B S E R V A T I O N

O B S E R V A T I O N S

The present study "EVALUATION OF MENSTRUAL AGE VERSUS RADIOLOGICAL ESTIMATION OF GESTATIONAL AGE BY PLAIN SKIAGRAMS IN THIRD TRIMESTER OF PREGNANCY" was carried out in Department of Radio-Diagnosis, Maharani Laxmi Bai Medical College Hospital, Jhansi. Total fifty pregnant women in their third trimester were studied.

The total No.of cases grouped according to the gestational age are shown in Table No. 1.

TABLE NO. 1

Shows No.of patients examined in different gestational period

Group	Week of gestation	No.of patients examined
1	29	0
2	30	0
3	31	2
4	32	3
5	33	3
6	34	4
7	35	6
8	36	8
9	37	6
10	38	7
11	39	5
12	40	6
<b>TOTAL</b>		<b>50</b>

I- FEMUR LENGTH :

In the skiagram taken in the third trimester, femur was invariably seen in profile view and usually clear of the maternal spine in both normal vertex and breech presentations. Only radio-opaque portion of the femoral shaft was measured. Epiphysis was not included in the measurement. The longer of the two femoral shaft measured was included in the study owing to lesser angulation error.

In 29 and 30 weeks of gestation, no patient was studied. In 31 week of gestation, two patients were studied and in both cases the femoral length was found to be 6.2 cm as shown in Table No. 2.

TABLE NO. 2

Shows femoral length in 31st week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
31	2	6.2	6.2	6.2
		6.2		

At 32 weeks of gestation, 3 patients were examined with femur lengths varying from 6.3 cm to 6.4 cm. Mean femoral length was found to be 6.4 cm.

TABLE NO. 3

Showing femoral length in 32nd week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
32	3	6.4		
		6.3	6.4	6.3 - 6.4
		6.4		

At 33 weeks of gestation, 3 patients were examined and femur length ranged from 6.4 cm to 6.6 cm. The mean of the femoral length was found to be 6.6 cm.

TABLE NO. 4

Showing femoral length in 33rd week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
33	3	6.6		
		6.6	6.6	6.4 - 6.6
		6.4		

At 34 weeks of gestation, 4 patients were examined. Femur length ranged from 6.7 cm to 7.0 cm. The mean of the femoral length was found to be 6.8 cm.

TABLE NO. 5

Showing femoral length in 34th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
34	4	7.0		
		6.8	6.8	6.7-7.0
		6.7		
		6.8		

At 35 weeks of gestation, six patients were examined. Mean femur length was 7.0 cm with a range of 6.8 to 7.4 cm.

TABLE NO. 6

Showing femoral length in 35th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
35	6	7.1		
		7.0		
		7.4	7.0	6.8-7.4
		7.0		
		6.8		
		6.8		

At 36 weeks of gestation, 8 patients were examined with femoral lengths showing wide variation from 6.6 cm to 7.4 cm. The mean of the femoral length was 7.2 cm.

TABLE NO. 7

Showing femoral length in 36th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
36	8	7.1		
		6.9		
		7.2	7.2	6.6-7.4
		7.6		
		6.6		
		7.4		
		7.2		
		7.2		

At 37 weeks of gestation, 6 patients were examined and range of femoral length was found to be 7.1 cm to 7.6 cm with a mean femoral length of 7.4 cm.

TABLE NO. 8

Showing femoral length in 37th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
37	6	7.3		
		7.6		
		7.4	7.4	7.1-7.6
		7.1		
		7.2		
		7.5		

At 38 weeks of gestation, seven patients were examined, femoral length was found to be in range of 7.4 cm to 7.8 cm. The mean of the femoral length was 7.6 cm.

TABLE NO. 9

Showing femoral length in 38th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
38	7	7.8		
		7.6		
		7.4		
		7.6	7.6	7.4-7.8
		7.6		
		7.7		
		7.8		

At 39 weeks of gestation, five patients were examined with femoral lengths ranging from 7.7 cm to 8.0 cm with a mean femoral length of 7.8 cm.

TABLE NO. 10

Showing femoral length in 39th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
39	5	7.7		
		7.8		
		7.7	7.8	7.7-8.0
		8.0		
		8.0		

At 40 weeks of gestation, six patients were examined. All patients delivered within a week of radiography. The femur length measured 8.0 cm or more with an exception of a single case where femur length was 7.8 cm. All the infants were mature at the time of birth.

TABLE NO. 11

Showing femoral lengths in 40th week of gestation.

Week of gestation	No. of cases	Femoral length in cm	Mean of femoral length in cm	Range of femoral length in cm
40	6	7.8		
		8.0		
		8.1	8.0	7.8-8.2
		8.1		
		8.2		
		8.0		

TABLE NO. 12

Showing average femur length at different gestational ages.

Gestational age in weeks	Average femur length in cm
31	6.2
32	6.4
33	6.6
34	6.8
35	7.0
36	7.2
37	7.4
38	7.6
39	7.8
40	8.0

The mean rate of growth of femoral shaft was approximately 2 mm for each week of gestation. It was observed that a foetus whose femoral shaft measured more than 7.2 cm was mature. There was wide discrepancy in the length of the femoral shaft and period of gestation.

### II- LENGTH OF LUMBAR CURVE

The foetal spine is usually visualized with clarity in good quality skiagram. The length of lumbar curve was measured concurrently with femoral length in all cases.

In 31 weeks of pregnancy, only 2 cases were studied. In both cases length of lumbar spine was found to be 4.0 cm.

TABLE NO. 13

Showing length of lumbar curve in 31st week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
31	2	4.0	4.0	4.0
		4.0		

In 32 weeks of gestation 3 cases were studied. The length of lumbar spine ranged between 4.0 to 4.2 cm with mean length of lumbar curve as 4.1 cm.

TABLE NO. 14

Showing length of lumbar curve in 32nd week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
32	3	4.1	4.1	4.0 - 4.2
		4.2		
		4.0		

In 33 weeks of gestation, again 3 cases were examined. The length of lumbar curve varied from 4.1 cm to 4.3 cm with mean length of 4.2 cm.

TABLE NO. 15

Showing length of lumbar curve in 33 weeks of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
33	3	4.1	4.2	4.1 - 4.3
		4.2		
		4.3		

In 34th week of gestation 4 patients were examined. Length of lumbar curve ranged from 4.2 cm to 4.4 cm. Mean of the lumbar curve was found to be 4.3 cm.

TABLE NO. 16

Showing length of lumbar curve in 34th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
34	4	4.2		
		4.3	4.3	4.2 - 4.4
		4.2		
		4.4		

In 35th week of gestation 6 patients were examined with mean length of lumbar curve as 4.4 cm. The length of lumbar curve varied from 4.1 to 4.6 cm.

TABLE NO. 17

Showing length of lumbar curve in 35th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
35	6	4.2	4.4	4.1 - 4.6
		4.4		
		4.1		
		4.5		
		4.6		
		4.6		

At 36th weeks of gestation a total of 8 patients were examined. Lumbar curve measured from 4.3 cm to 5.2 cm with a mean length of 4.6 cm.

TABLE - 18

Showing length of lumbar curve in 36th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
36	8	4.5		
		4.9		
		4.6	4.6	4.3 - 5.2
		4.3		
		5.2		
		4.5		
		4.6		
		4.6		

At 37th week of gestation a total of 6 patients were examined. Length of lumbar curve ranged between 4.6 cm to 5.2 cm. Mean of the length was found to be 4.8 cm.

TABLE NO. 19

Showing length of lumbar curve in 37th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
37	6	4.7		
		4.6	4.8	4.6 - 5.2
		4.6		
		5.0		
		5.2		
		4.8		

At 38th week of gestation 7 patients were examined. Length of the lumbar curve varied from 4.7 cm to 5.3 cm. Mean length of lumbar curve was 5.0 cm.

TABLE NO. 20

Showing length of lumbar curve in 38th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
38	7	4.7		
		5.1		
		5.3	5.0	4.7- 5.3
		5.1		
		5.0		
		4.8		
		4.8		

At 39th week of gestation 5 patients were examined. The length of lumbar curve varied from 4.8 cm to 5.4 cm with mean length of 5.2 cm.

TABLE NO. 21

Showing length of lumbar curve in 39th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
39	5	5.2		
		5.2	5.2	4.8 - 5.4
		5.4		
		5.2		
		4.8		

At 40th week of gestation 6 patients were examined. The length of lumbar curve ranged between 5.2 cm to 5.6 cm. Mean of the lumbar length was found to be 5.4 cm.

TABLE NO. 22

Showing length of lumbar curve in 40th week of gestation

Week of gestation	No. of cases	Length of lumbar curve in cm	Mean in cm	Range in cm
40	6	5.6		
		5.4	5.4	5.2 - 5.6
		5.2		
		5.3		
		5.5		
		5.5		

TABLE NO. 23

Showing mean lengths of lumbar curve at different gestational ages.

Gestational Age (in weeks)	Mean lengths of lumbar curve in cm
31	4.0
32	4.1
33	4.2
34	4.3
35	4.4
36	4.6
37	4.8
38	5.0
39	5.2
40	5.4

Table 23 shows that from 31 to 35 weeks of gestation the length of lumbar curve increased with a relatively slower rate, approximately 1 mm per week later, from 35-40 weeks of gestation it grows at a rate of approximately 2 mm per week.

Distal femoral epiphyseal ossification center :

The appearance of ossification center of the lower end of the femur was seen earliest at 34th week of gestation in 1 out of 4 cases studied. Distal femoral epiphysis was seen in one of six patients examined at 35th week of gestation. However from 36th week of gestation, a large majority of cases (90.6%) showed the presence of distal femoral epiphysis. At 40 weeks of gestation, presence of distal femoral epiphysis was a constant feature. It was noticed that the size of distal femoral epiphysis increased proportionally with increase in gestation period. In the cases where lower femoral epiphysis was absent, upper tibial epiphysis was also absent.

TABLE NO. 24

Showing distal femoral epiphysis in different weeks of gestation period.

Period of gestation in weeks	No. of patients	Presence of distal femoral epiphysis No. of patients
31	2	Nil
32	3	Nil
33	3	Nil
34	4	1
35	6	1
36	8	8
37	6	5
38	7	6
39	5	4
40	6	6

Proximal tibial epiphyseal ossification center :

The appearance of proximal tibial ossification center was seen earliest at 38 weeks of gestation, when it was present in 2 out of 7 cases (28.57%). At 39 weeks of gestation, 3 out of 5 cases showed the presence of proximal tibial epiphyseal ossification center. At 40 weeks of gestation a total of 5 out of 6 cases (86.6%) showed the presence of proximal tibial ossification center. Thus this center was noted in 55.5% of the cases examined from 38th weeks of gestation onwards. In no case proximal tibial epiphysis was present in the absence of lower femoral epiphysis.

TABLE NO. 25

Showing proximal tibial epiphyseal ossification center in different weeks of gestation period.

Period of gestation in weeks	No. of patients	Presence of proximal tibial epiphysis No. of patients
31	2	Nil
32	3	Nil
33	3	Nil
34	4	Nil
35	6	Nil
36	8	Nil
37	6	Nil
38	7	2
39	5	3
40	6	5

FETAL DATING USING MULTIPLE PARAMETERS :

In 1982 Hadlock, F.P. et al while estimating fetal age by ultrasonography reported that significant improvements in the observed variability in predicting menstrual age from fetal measurement can be achieved when two or more of these measurements are used in combination to produce a composite age estimate. The rationale for this approach was based on the fact that if one uses only a single fetal measurement to predict menstrual age and makes an imaging or measurement error, the magnitude of error in age prediction could be potentially greater than the reported variability for that parameter.

The method described by Hadlock (1982), when applied to our studies, was found to be sufficiently valid to be useful. The composite age estimate obtained by using the twin parameters of lumbar curve length and femur length, showed significant improvements in the observed variability.

Composite age estimate was obtained by taking average of the two individual estimates of the age. Accordingly-

$$\text{Composite age estimate} = \frac{\text{Fetal age according to femur length} + \text{Fetal age according to lumbar curve length}}{2}$$

TABLE NO. 26

Showing estimation of fetal age by femur length, lumbar curve length and using multiple parameters (composite age estimate).

Sl. No.	Femur length in cm	Lumbar curve length in cm	Fetal age according to femur length in weeks A	Fetal age according to lumbar curve len- gth in weeks B	Composite age estimate in weeks $\frac{A+B}{2}$	Gestational age in weeks according to menstrual history
1.	6.2	4.0	31	31	31	31
2.	6.2	4.0	31	31	31	31
	6.4	4.1	32	32	32	32
4.	6.3	4.2	31.5	33	32.25	32
5.	6.4	4.0	32	31	31.5	32
6.	6.6	4.1	33	32	32.5	33
7.	6.6	4.2	33	33	33	33
8.	6.4	4.3	32	34	33	33
9.	7.0	4.2	35	33	34	34
10.	6.8	4.3	34	34	34	34
11.	6.7	4.4	33.5	35	34.25	34
12.	6.8	4.2	34	33	33.5	34
13.	7.1	4.2	35.5	33	34.25	35
14.	7.0	4.4	35	35	35	35
15.	7.4	4.1	37	32	34.5	35

Sl. No.	Femur length in cm	Lumbar curve length in cm	Fetal age according to femur length in weeks A	Fetal age according to lumbar curve len- gth in weeks B	Composite estimate in weeks	Gestational age in weeks according to menstrual history
					$\frac{A + B}{2}$	
16.	7.0	4.5	35	35.5	35.25	35
17.	6.8	4.6	34	36	35	35
18.	6.8	4.6	34	36	35	35
19.	7.1	4.5	35.5	35.5	35.5	36
20.	6.9	4.9	34.5	37.5	36	36
21.	7.2	4.6	36	36	36	36
22.	7.6	4.3	38	34	36	36
23.	6.6	5.2	33	39	36	36
24.	7.4	4.5	37	35.5	36.25	36
25.	7.2	4.6	36	36	36	36
26.	7.2	4.6	36	36	36	36
27.	7.3	4.7	36.5	36.5	36.5	37
28.	7.6	4.6	38	36	37	37
29.	7.4	4.6	37	36	36.5	37
30.	7.1	5.0	35.5	38	36.75	37
31.	7.2	5.2	36	39	37.5	37
32.	7.5	4.8	37.5	37	37.25	37
33.	7.8	4.7	39	36.5	37.75	38
34.	7.6	5.1	38	38.5	38.25	38
35.	7.4	5.3	37	39.5	38.25	38

Sl. No.	Femur length in cm	Lumbar curve length in cm	Fetal age according to femur length in weeks A	Fetal age according to lumbar curve len- gth in weeks B	Composite age estimate in weeks $\frac{A+B}{2}$	Gestational age in weeks according to menstrual history
36.	7.6	5.1	38	38.5	38.25	38
37.	7.6	5.0	38	38	38	38
38.	7.7	4.6	38.5	37	37.75	38
39.	7.8	4.8	39	37	38	38
40.	7.7	5.2	38.5	39	38.75	39
41.	7.8	5.2	39	39	39	39
42.	7.7	5.4	38.5	40	39.75	39
43.	8.0	5.2	40	39	39.5	39
44.	8.0	4.8	40	37	38.5	39
45.	7.6	5.6	39	40	39.5	40
46.	8.0	5.4	40	40	40	40
47.	8.1	5.2	40	39	39.5	40
48.	8.1	5.3	40	39.5	39.75	40
49.	8.2	5.5	40	40	40	40
50.	8.0	5.5	40	40	40	40

Thus it is clear from the table that variability of age

estimation, using a single parameter, is upto 3 weeks, while with composite age estimation method this variability is found to be reduced to within a week.



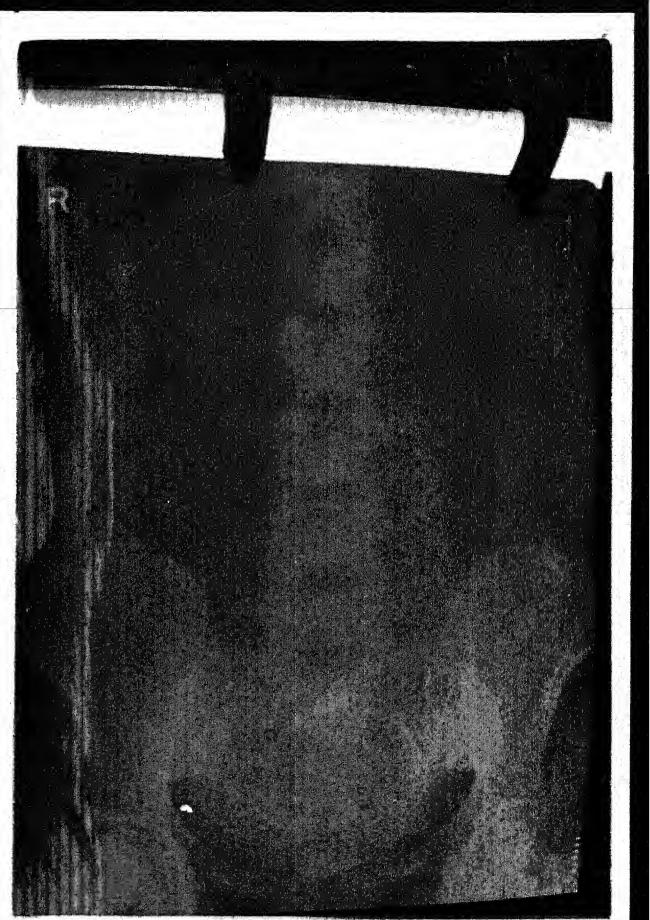
CASE NO. 48 : SHOWING FEMUR  
AND LUMBAR CURVE AT 40 WEEKS  
OF GESTATION. LOWER FEMORAL  
AND UPPER TIBIAL EPIPHYSIS  
ARE PRESENT.



CASE NO.49 : SHOWING FEMUR  
AND LUMBAR CURVE AT 40 WEEKS  
OF GESTATION. LOWER FEMORAL  
EPIPHYSIS IS PRESENT.



CASE NO. 24 : SHOWING FEMUR  
AND LUMBAR CURVE AT 36 WEEKS  
OF GESTATION. LOWER FEMORAL  
EPIPHYSIS IS PRESENT.



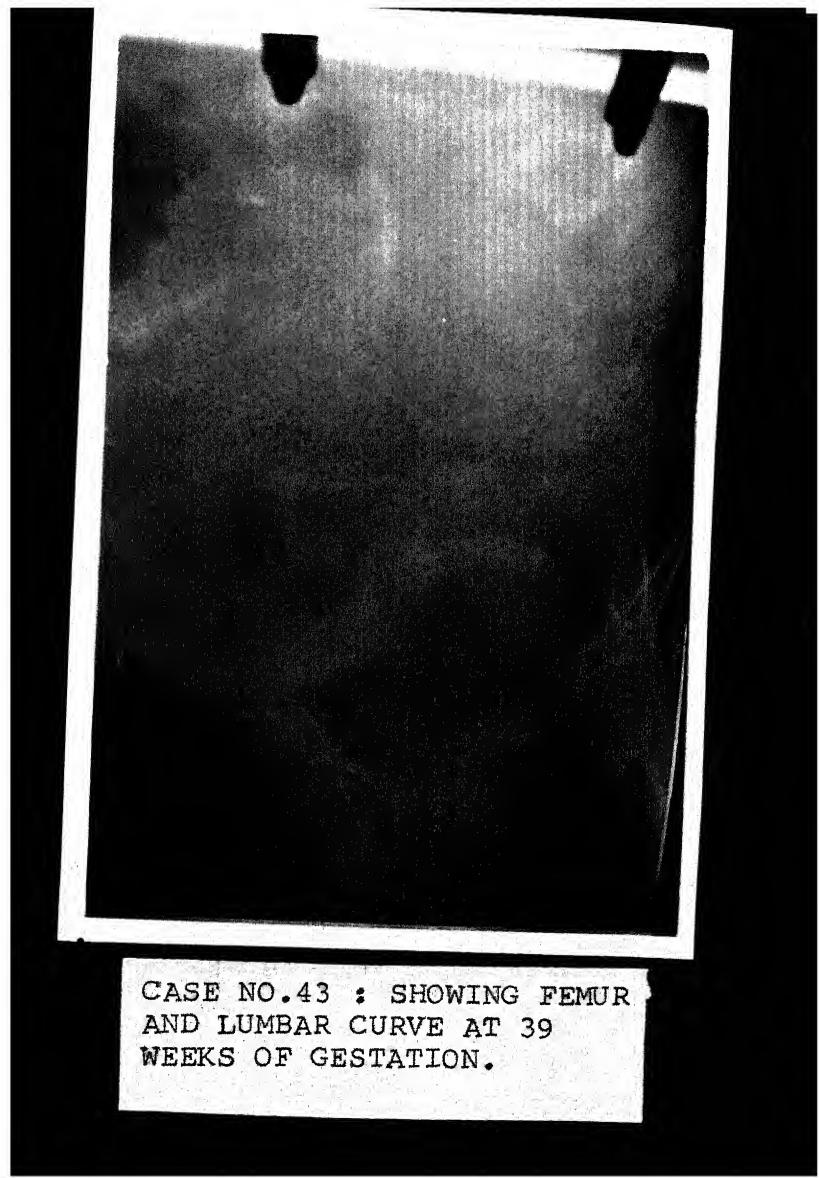
CASE NO. 14 : SHOWING FEMUR  
AND LUMBAR CURVE AT 35 WEEKS  
OF GESTATION. LOWER FEMORAL  
EPIPHYSIS IS PRESENT.



CASE NO. 42 : SHOWING FEMUR  
AND LUMBAR CURVE AT 39 WEEKS  
OF GESTATION. LOWER FEMORAL  
AND UPPER TIBIAL EPIPHYSIS  
ARE PRESENT.



CASE NO. 9 : SHOWING FEMUR  
AND LUMBAR CURVE AT 34  
WEEKS OF GESTATION.



CASE NO.43 : SHOWING FEMUR  
AND LUMBAR CURVE AT 39  
WEEKS OF GESTATION.



CASE NO. 29 : SHOWING FEMUR  
AND LUMBAR CURVE AT 37 WEEKS  
OF GESTATION. LOWER FEMORAL  
EPIPHYSIS IS PRESENT.



CASE NO. 13 : SHOWING FEMUR  
AND LUMBAR CURVE AT 35 WEEKS  
OF GESTATION.

\*\*\*\*\*  
\* D I S C U S S I O N \*  
\*\*\*\*\*

DISCUSSION

Various methods have been devised to estimate fetal maturity in utero. None of the methods can predict fetal maturity with certainty. Under certain circumstances radiological estimation of fetal maturity becomes necessary. These include -

1. When the menstrual history is uncertain or unknown and prolongation of pregnancy may be contraindicated for any reason.
2. In the presence of fetal or maternal complications, to estimate an appropriate time for possible termination of the pregnancy.
3. To ascertain the correctness of the menstrual history in anticipation of repeat Cesarean section.
4. In sensitized Rh- negative mothers with a rise in antibody titer, anticipating the possibility of rapid obstetric action (Intrauterine transfusion, termination of pregnancy).
5. When there is reasonable suspicion of prolongation of pregnancy beyond the expected date of confinement to determine the possibility of postmaturity.

6. When there is a significant age-size discrepancy in the fetus, to estimate fetal maturity and the possibility of fetal abnormalities.

While there may be other reasons for obtaining antepartum films of the abdomen in pregnancy like lie, presentation, number of foetuses or any congenital abnormalities.

In this series, the clinical data were carefully scrutinized and patients were excluded from the series if there was any doubt as to the date of the last menstrual period, or if their menstrual cycle had been irregular.

Hodges (1937), reported on parallax radiological measurement of the femoral shaft in approximately 100 human fetuses, the age ranging from 16 to 38 weeks. The method was mathmatically complicated and the number of cases after 30 weeks was small. However, these methods have not stood the test of general clinical usage because of the various problems concerning radiological techniques, the use of complicated formulas or the unavailability of charts and tables.

Brandfass and Howland (1967), describe a simple method of "Determination of fetal weight by long bone measurements". By measuring the long bones on pelvimetry or anteroposterior maternal abdominal films, and compairing

them with measurements obtained from films of new born infants, they predicted whether an infant would weigh more or less than 2,250 gm with about 90 percent accuracy.

According to them, for femur lengths measuring 8.6 cm or more, the foetus should weigh 2,250 gm or more.

In our study no foetus had femur measuring more than 8.2 cm. The difference may be due to difference of positioning.

R.H. Owen (1970), took the PA film with anode film distance of 36 inches or 90 cm. Measurements were taken directly from the films with no corrections for magnification. Owen reported that in the last weeks of pregnancy the femur grew at 1 mm a week. In present study the method used was the same except that the FFD used was 40 inches or 100 cm. Rate of growth of femur length was observed to be approximately 2 mm per week which is about 1 mm per week more than that reported by Owen.

Martin and Higginbottom (1971), studied only the femur. They stated that a 15 degree angulation can be ignored without introducing a significant error. They also suggested that a repeat film can be exposed after external manipulation, if desired. The growth rate of femur as reported by these authors is 3.0 mm per week. In our study,

the rate of femur growth observed was less by about 1.0mm per week as compared to that reported by these authors.

J.G.B. Russell et al (1972), examined films of 217 women in a prone position and measurement were made directly from the films. Length of fetal long bones were measured. They reported a mean rate of growth of about 1.5 mm per week. This is about 0.5 mm per week less than that observed by us.

Kumar and Chawla (1978), measured femur length in films of 86 cases taken in postero-anterior oblique position. Film focus distance was 100 cm. They observed wide variation in the length of the femoral shaft and the period of gestation but made a conclusion that femoral shaft measuring more than 7.6cm was of more than 36 weeks of gestation. In present study, we also observed a wide variation in the lengths of femoral shafts and the corresponding periods of gestation and that femoral shafts measuring 7.2 cm or more corresponded to 36 weeks of gestation. This deviation may be due to difference of positioning of the patient in the two studies. Moreover their findings were based on the examination of the X-ray plates taken during third trimester of pregnancy, for various indications other than fetal maturity.

Fagerberg and Ronema (1957), deduced the gestational age from crown to heel length obtained by measuring the length of lumbar spine. Alan J. Margolis (1967), measured the lumbar vertebral length from postero-anterior radiographs of pregnant women. They stated that the measured lumbar vertebral length yeilds a mean figure ( $\pm 5\text{CM}$ ) for total length; reference to an intrauterine growth chart will yeild an approximation of fetal maturity. They reported that fetal lumbar length of 52 mm or more was clinically significant.

In the present study, we have calculated the gestational age directly from the measurements of length of lumbar curve. Thus, our method differ's from that adopted by Fagerberg and Ronema (1957), and Alan J. Margolis (1967), where the gestational age was calculated from crown to heel length obtained by measurement of the lumbar spine.

Kumar, S. and Chawla (1978), measured the lumbar vertebrae from the upper border of  $L_1$  to lower border of  $L_5$  in 86 films taken postero-anterior oblique position. They found that a foetus whose lumbar vertebral length was more than 5.1 cm was of more than 36 weeks of gestation. In present study this figure was 4.7 cm. Discrepancy may be due to the position of patient during the exposure of films.

Amos Christie et al (1950), studied X-ray of the knees in 1,112 newborn infants and concluded that distal femoral epiphysis appear at 36 weeks of gestation and weighing more than 2,500 grams. In the second part of their study by examining the 100 antepartum X-ray films they made an observation that if maturity of the foetus was determined solely from the presence or absence of the centre, one would make an appreciable error in about 20 percent of the cases when only the distal femoral epiphysis was present.

In the present study the time of appearance of the distal femoral epiphysis was at 36 weeks of gestation being similar to that observed by Amos Christie et al. Out of 20 patients in whom only the distal femoral epiphysis was present, 2 were below 36 weeks of gestation giving an error of 10% in the estimation of fetal maturity.

Duncan Murdoch and Cope (1957), examined radiographs of the knees in 100 new born mature infants and reported the presence of lower femoral epiphysis in 99 of the 100 cases examined. In present study lower femoral epiphysis was present in 100% of cases examined at 40 weeks of gestation who were delivered within a week of radiography.

Hartley (1957), observed that lower femoral epiphysis appear at 36 weeks and was present in over 80 percent of infants from the thirty sixth week of gestation onwards. In present study distal femoral epiphysis appeared at 36 weeks of gestation and was present in 90 percent of foetuses from the 36 weeks onward.

Beridge, F.R. (1958), reported absence of lower femoral ossification centres after 36 weeks of gestation in 3 out of 200 foetuses examined at antepartum films. However the lower femoral ossification center was reported to be present in 5 of the 200 cases studied before 36 weeks. In the present study, absence of lower femoral epiphyseal center, after 36 weeks of gestation was noticed in 3 out of the 50 foetuses studied at antepartum films. Presence of these centers before 36 weeks was seen in 2 of the 50 cases studied.

Melvyn H. Schreiber (1962), have estimated 98.6 percent reliability in the prediction of maturity from visualization of the lower femoral epiphysis on a film of knee joints of newly born infants. However in present study an accuracy of 93.9 percent has been estimated for the presence of lower femoral epiphysis.

The difference between the study of Schreiber and present study is that. the former was carried out postnatally on newborns while the present study involved antenatal radiographic assessment.

Schreiber et al (1963), reported that when antenatal radiographs were taken, lower femoral epiphysis was identified in 80% cases while postnatal radiographs of same foetus showed presence of femoral epiphysis in 100% of cases. This variation was probably due to lack of clarity of epiphysis in antenatal radiograph.

In present study this center was present in 90.6 percent of the radiographs obtained prenatally from 36 weeks of gestation onward.

Dee, P.M. and Parkin, J.M. et al (1966), studied postpartum knee radiographs of 109 cases limited to the age group of 36 weeks and after. The lower femoral ossification center was found to be absent in two cases before 38 weeks of gestation while it was universally present after 38 weeks of gestation. In present study this center was not seen in one case at 37 weeks of gestation and was also found absent in one case at 38 and another at 39 weeks of gestation.

J.G.B. Russell (1967) stated that the time of appearance of the lower femoral ossification center was 37 weeks rather than 36 weeks of gestation. In the present study however presence of this center was noted as early as 34 weeks of gestation in one case. However from 36 weeks of gestation, a large majority of cases showed the presence of distal femoral epiphysis.

Kumar and Chawla (1978) studied 100 films of pregnant women in third trimester of pregnancy and observed that the centers for the lower end of femur appear at 36 weeks of gestation. In our study, similar findings were observed except in 2 cases where the appearance of this epiphysis was noted at 34 and 35 weeks of gestation respectively.

Amos Christie (1950), studied X-ray of the knees in 1,112 newborn infants and concluded that proximal tibial epiphysis appear at 39 to 40 weeks of gestation. In present study time of appearance of the proximal tibial epiphysis was at 38 weeks which is a week earlier to that reported by Amos Christie.

Duncan Murdoch and Cope (1957), examined radiographs of the knees in 100 new born mature infants and reported the presence of upper tibial epiphysis in 72 of the 100 cases examined. In no case was it present in the absence of the lower femoral epiphysis. In present study it was present in 5 out of 6 cases (83%) at 40 weeks of gestation.

Hartley (1957), observed that proximal tibial epiphyseal ossification center appears at about 38 weeks of gestation. Findings similar to those reported above were observed in the our study.

Beridge, F.R. (1958), studied 200 fetuses at antepartum films and reported the appearance of upper tibial ossification centers as early as 32 weeks of gestation. This was in variance with findings of the present study in which appearance of this center was noted at the earliest in 38th week of gestation.

Dee, P.M. and Parkin, J.M. et al (1966), studied 190 radiographs of infants knee taken just after birth. The upper tibial ossification center was absent in 12 out of 95 cases after 38 weeks and it was present in 8 out of 14 cases. In present study the center was absent in 8 out of 18 cases studied from 38 weeks onwards. In no case this center was found to be present before 38 weeks of gestation.

Kumar, S. and Chawla (1978), studied 100 films of third trimester and observed that the centers of upper end of tibia appear at 38 weeks of gestation, observations similar to those of our study.

Many authors utilize a combination of measurements in an effort to increase reliability. Ball (1935), used the circumference of the head measured with a "Pelvicocephalometer". His work was extended by Hodges (1937), who used in addition, the occipitofrontal and biparietal diameters and the length of the calcified femoral shaft. It requires stero pairs and the use of distortion charts. Their figures are derived from data on fetal growth rates by Scammon and Calkins (1929). Stockland (1961), produced tables using the length of the spine, the length of the skull, the antero-posterior and transverse diameters of the uterus, in addition to the biparietal and occipitofrontal diameters and their combinations.

A closer weight estimation results from these multiple parameter analyses. The procedure is time consuming and the low feasibility rate limit a wide application of all these procedures.

In the present study it was seen that all the four parameters can easily be obtained from a single film of the mothers abdomen, and composite age estimation can be done using simple calculation. The overall accuracy and the reliability of the radiological estimation may be enhanced by using composite age estimate which significantly improves the observed variability in predicting foetal age from foetal measurements than from any single parameter alone.

-----

\*\*\*\*\*  
SUMMARY AND CONCLUSIONS  
\*\*\*\*\*

S U M M A R Y   A N D   C O N C L U S I O N

The present study "Evaluation of menstrual age versus radiological estimation of gestational age by plain skiagrams in third trimester of pregnancy" was carried out in Department of Radio-diagnosis, Maharani Laxmi Bai Medical College and Hospital, Jhansi. The present study was undertaken because of the need for more accurate prediction of foetal maturity by radiological methods. Ultrasonography while carrying the advantage of being non ionizing suffers from the potential disadvantage of a high cost factor, and scarce availability of this modality in under developed areas of Bundelkhand region had placed the responsibility for assessment of gestational age more on X-ray techniques, which are still widely employed.

A total of fifty pregnant women in their third trimester were radiographed in postero-anterior projection. All the cases included in the study were patients with a reliable knowledge of date of last menstrual period. The following parameters were recorded from the films selected for the study.

- 1- Femur length
- 2- Lumbar curve length

3- Presence or absence of distal femoral epiphysis

4- Presence or absence of proximal tibial epiphysis

Femur length : The mean rate of growth of femoral shaft was approximately 2mm for each week of gestation.

Lumbar curve length : From 31 to 34 weeks of gestation the length of lumbar curve increased with a relatively slower rate, approximately 1 mm per week. Later from 35-40 weeks of gestation it grows at the rate of approximately 2 mm per week.

Distal femoral epiphyseal ossification center : From 36 weeks of gestation, a large majority of cases (90.6%) showed the presence of distal femoral epiphysis. In two cases the presence of distal femoral epiphysis was noted before 36 weeks of gestation. Thus the presence of distal femoral epiphysis is associated with an accuracy of 93.9%.

Proximal tibial epiphyseal ossification center : Proximal tibial ossification center was seen to be present at the earliest at 38 weeks of gestation. Thus the presence of this center is indicative of a fetal maturity of not less than 38 weeks of gestation.

Composite age estimation : Composite age estimate was obtained by taking average of two individual estimates of age. Accordingly -

$$\text{Composite age estimate} = \frac{\text{Fetal age according to femur length} + \text{Fetal age according to lumbar curve length}}{2}$$

The variation in age estimation, using a single measurement, is upto 3 weeks, while in composite age estimation the variability is found to be reduced to within a week. The presence of lower femoral and upper tibial epiphysis further reinforces the accuracy of estimation of gestational age by foetal measurements.

The present study permits us to conclude that using a combination of measurements and signs in an individual case, it should be possible to predict infant maturity with a high degree of accuracy.

Since radiologic examinations during pregnancy produce unwanted amounts of radiation to the fetus and to the maternal gonads, the consequences of such an exposure must be weighed against the need for accurate estimation of foetal development in order that appropriate obstetric management may be instituted.

Over all when the newer modalities like ultrasonography is not available, radiological assessment of foetal age becomes a must and accuracy of age estimation by radiological method is quite accurate.

-----

\*\*\*\*\*  
B I B L I O G R A P H Y  
\*\*\*\*\*

### B I B L I O G R A P H Y

1. Ball, R.P., and Marchbanks, S.S. : Roentgen pelvimetry and fetal cephalometry; a new technique. *Radiology* 24 : 77-84, 1935.
2. Berridge, F.R. and Eton, B. : The accuracy of radiological estimation of foetal maturity. *J. Obstet. Gynaec. Brit. Emp.*, 65 : 625-630, 1958.
3. Brandfass, R.T. and Howland, W.J. : Determination of fetal weight by long bone measurements. *Obstet. and Gynaec.*, 29 : 230-234, 1967.
4. Christie, A., Martin, M., Williams, E.L., Hudson, G., and Lanier, J.C. : The estimation of fetal maturity by roentgen studies of osseous development. *Amer. J. Obstet. Gynec.*, 60 : 133-139, 1950.
5. Cope, I., and Murdoch, J.D. : The estimation of fetal maturity. *J. Obstet. Gynaec. Brit. Empl.*, 65 : 56-57, 1958.
6. Dee, P.M., Parkin, J.M. and Simpson, W. : A study of some radiological criteria used in assessing the gestational age of the human infant. *Clinical Radiology*, 47 : 125-131, 1966.
7. Fagerberg, S., and Ronema, J. : Radiological determination of fetal length by measurement of the lumbar spine. *Acta Obstet. and Gynec. Scand.*, 38 : 333-339, Supplements 1-4, 1959.

8. Hadlock, F.P. et al : Computer assisted analysis of fetal age in the third trimester using multiple fetal growth parameters, J.C.U. 11 : 313, 1983.
9. Hartley, J.B. : Radiological estimation of fetal maturity. Brit. J. Radiology, 30 : 561-576, 1957.
10. Hodges, P.C. : Roentgen pelvimetry and fetometry. Amer. J. Roentgen., 37 : 644-662, 1937.
11. Kumar, S. and Chawla, S. : Radiographic assessment of fetal maturity. Indian J. Radiology, 32 : 19-24, February, 1978.
12. Margolis, Alan, J. and Voss, Richard, G. : A method for radiologic detection of fetal maturity. Amer. J. Obstet. and Gynec., 101 : 383-389, 1968.
13. Martin, R.H., Higginbottom, J. : A clinical and radiological assessment of fetal age. J. of Obstet. and Gynec. of British Commonwealth, 78 : 155-162, 1971.
14. Murdoch, D. and Cope, I. : Ossification centres as evidence of fetal maturity. J. Obstet. Gynaec. Brit. Emp., 64 : 382-384, 1957.
15. Owen, R.H. : The estimation of fetal maturity. 44 : 531-534, 1971.

III

16. Russell, J.G.B. : Radiological assessment of fetal maturity. J. of Obstet. and Gynaec. of the British Commonwealth. 76 : 208-219, 1969.
17. Russell, J.G.B. and Mattison, A.E., Easson, W.T., Clarke, D., Sharpe, T., and McGough, T. : Skeletal dimensions as an indication of fetal maturity. Brit. Jour. Radiology. 45 : 667-669, 1972.
18. Schreiber, M.H., Menachof, Louis, Gunn, W.G., Biehusen, F.C. : Reliability of visualization of the distal femoral epiphyses as a measure of maturity. Am. J. of Obstet. and Gynaec. 83 : 1249-1250, 1962.
19. Schreiber, M.H., Nichols, M.M. and McGanity, W.J. : Epiphyseal ossification center visualization. Its value in prediction of fetal maturity. J.A.M.A. 184 : 504-507, 1963.
20. Schreiber, M.H., and Morettin, L.B. : Antepartum prediction of fetal maturity. Radiological clinics of North America 5 : 21-28, 1967.
21. Stockland, L. and Marks, S.A. : A new method of fetal weight determination. Amer. J. Roentgen, 86 : 425-432, 1961.

-----